Natural and Constructed Defenses in Fijian Fortifications

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THE EARLIEST EUROPEAN EXPLORERS to sail into Fijian waters, e.g., Tasman in 1643, Cook in 1772, Bligh in 1789, and Wilkes in 1845, were very cautious when making landfall. These islands were known as the "Cannibal Islands," and their neighbors, Tongans and Samoans alike, feared the ferocious nature of the Fijian warriors. Oral histories recorded during the past centuries, in *Tukutuku Raraba ni Veitiarogi ni Vanua*[1], also document the Fijian predilection to war and record the succession of treacherous plots and battles that resulted in the modern *Yavusa*, or patrilinial clan system. European traders, settlers, and missionaries were also witness to Fijian conflicts and brutality, and as can be gleaned from the following excerpt, the contents of their diaries shed light into the competitive nature of traditional Fijian society, and also the institutionalization of warfare and cannibalism.

> When on his feet, the Fijian is always armed; when working in his garden, or lying on his mat, his arms are always at hand. This, however, is not to be attributed to his bold or choleric temper, but to suspicion and dread. Fear arms the Fijian. His own heart tells him that no one could trust him and be safe, whence he infers that his own security consists in universal mistrust of others. (Williams 1858 : 43)

For the most part, scholars such as Williams (1858 : 43–59), Routledge (1985), and Clunie (1977 : 4–7) have provided historical accounts for why this level of tension existed, focusing on the political moves of power-hungry Fijian chiefs and the "checks and balances" system of the Fijian social hierarchy. However, less progress has been made in determining the origins of this competition and aggression, and how it affected the development of Fijian society.

Recently, archaeology has uncovered evidence that indicates the extent of warfare in the islands. Encountered in the earliest waves of human expansion into remote Oceania (c. 3500–3200 B.P.), the first settlers in Fiji possessed the cultural milieu that signifies Lapita: a coastal adaptation and dentate-stamped ceramics (Golson 1961; Green 1982; Terrell 1996). Archaeological research indicates that groups of people established coastal settlements on the main island of Viti Levu between 2800 and 3200 B.P. (Birks and Birks 1967; Birks 1973; Mead et al. 1975;

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Hunt 1986). However, the precise details of the later settlement of Fiji, particularly the development of wetland and dryland root-crop agriculture and the expansion of settlements into the remote and rugged valleys of the interior, are still being discovered. Surveys and excavations by Gifford (1951), Palmer (1967), and Frost (1974), and more recently by Parry (1977, 1981, 1987), Best (1984, 1993), Crosby (1988), and Kuhlken (1994) have documented the widespread distribution of elaborate hilltop and lowland fortifications in the interior by 1000 B.P., some of which are associated with sophisticated irrigation systems for terrace agriculture. These forts, identified on the ground and from the air by the presence of constructed earthworks such as terraces, ditches, banks, and walls, bear mute testimony to the pervasiveness of warfare.

Of particular note are J. Parry's monumental studies of fortifications in Fiji. By analyzing aerial photographs, Parry identified and documented the distribution of fortifications and field systems in the Rewa, Navua, and Sigatoka valleys. Parry's analyses of these data have made a significant contribution to what is known about Fijian prehistory, and are also a source for future research. The following study initiates a new series of analyses of Parry's data with a geographic information system (GIS). The first set of analyses focus on the location of fortifications across the landscape, paying special attention to their proximity to agricultural resources. The results of these analyses will be compared to conclusions made by Parry, and also to evolutionary ecological hypotheses. The second set of analyses will focus on the utilization of natural defenses inherent in the topography, and how they reveal different strategies for acquiring resources. The results of these two sets of analyses give a new perspective on Fijian prehistory, and also reveal the evolutionary processes at work in prehistoric human societies.

THEORETICAL CONSIDERATIONS

Since the late nineteenth century, Darwin's theory of natural selection has provided a very robust framework for the exploration of historical change, and it has become the guiding principle for several fields of scientific study (Mayr 1991: 141). According to the theory of natural selection, the diversity of organisms extant in the world at any one time is the result of the differential persistence of heritable traits. The varying rates of replicative success of organisms in a population are responsible for changes that can be observed in successive generations. These changes are referred to as adaptations, and the process of continued adaptation over generations is termed evolution. In principle, natural selection leads to evolutionary change when these three conditions exist: (1) traits vary within populations, (2) traits are inherited by offspring, and (3) traits exhibit differential fitness over time and space.

Although the principles have changed only slightly, Darwin's theory of natural selection has benefited from the advent of genetics (Mayr 1991: 132–140). Traits are now divided into genotypes (chemical codes inherited by each individual through the process of reproduction), and phenotypes (those characteristics of an organism, including behavior, that interact with the environment). This division more accurately depicts the transmission of inherited and acquired characteristics among living organisms and within complex adaptive systems.

The theory of natural selection was a revolutionary concept for the biological sciences, and it has been applied almost universally to explain how and why biological diversity evolves and differentially persists through time and space. The more recent incorporation of genotypes and phenotypes has also broadened the scope of Darwinian theory, allowing it to be applied to the evolution of behaviors as well as organisms. Evolutionary ecology is a product of this development. Akin to behavioral ecology, evolutionary ecology focuses on the evolution of behaviors (extensions of the phenotype) that are geared toward increasing fitness and reproductive success. These behaviors are also subject to selection, and they will persist differentially across time and space. Early evolutionary ecologists such as MacArthur (1961), Brown (1964), Crook and Gartlan (1966), Alexander (1974), Durham (1976), and Dyson-Hudson and Smith (1978) wrote extensively about the intertwined relationships that arise between the environment and populations, e.g., the competition for critical resources fueling the development of strategies for increasing survival, fitness, and replicative success. These relationships likely operate on both the individual and group level, and ultimately provide the organism or group of organisms a suite of choices that can be used to manipulate the surrounding environment. The varying rates of success of these choices are explained by natural selection operating on behavioral variability.

Consequently, evolutionary ecological models that deal with the origins of warfare are focused on the functional relationships between behavior and critical resource distribution, and the competitive strategies that arise, i.e., the costs and benefits of territoriality and group formation (Durham 1976; Boone 1983, 1992). Accordingly, archaeological cases that utilize evolutionary ecological models must infer these processes through the remains of prehistoric cultures. In this case a differentiation must be made between the environment and the physical artifacts of human behavior in order to provide the details necessary for analysis. Therefore, the data sets in this study have been segregated into two groups: (1) the distribution of fortifications across the landscape and their proximity to natural resources, and (2) the nature of fortifications themselves, including constructed and natural defenses provided by physical topography. The division between these two bodies of data is essential to determining the ecological factors that affect human behavior, and also the behavioral strategies that evolved within the environment.

AN EVOLUTIONARY ECOLOGICAL PERSPECTIVE ON PREHISTORIC SETTLEMENT, COMPETITION, AND WARFARE

The following premises outline an evolutionary perspective on the origins of competition in Fiji, and also track the development of subsistence strategies in a chronically aggressive environment. Each point in the model will be followed by situations that will be examined in the course of this study.

The initial settlement of the region can be analyzed via a scramble competition model. This model dictates that the environment contained a limited number of resources, and it was advantageous (in terms of increased probability of survival and reproduction) to obtain and exploit those resources. Therefore, the first individuals on the scene would have gained exclusive access to areas where resources are the most dense and predictable (Boone 1992: 315). For Fiji, it is assumed that wetland and dryland root-crop agriculture (predominantly taro and yams) allowed for post-Lapita expansion into the interior, and that this technology remained the main mode of subsistence. Thus, subsistence centered on the production of these resources, and arable land that was most suited to producing high, predictable yields would have been the most extensively exploited. The distribution of sedimentary deposits and the nature of their situation will be examined in this Fijian case study, and these data will be compared to the overall distribution of land that shows signs of prehistoric cultivation.

Evolutionary ecology often dictates that competition will occur when a population begins to grow and expand beyond the areas of initial colonization. According to Brown (1964), natural selection favors territoriality when there is a relative advantage to it, e.g., when the costs of defending a resource are less than the benefits that would be gained by its exclusive use. Thus, territoriality would be advantageous in areas where resources are dense and predictable. It would follow then that archaeological features related to aggression and defense would occur in proximity to the best arable land (wetland and dryland). In this case study, the distribution of defensive sites across the Fijian landscape will be analyzed in order to determine their accordance with this premise.

Evolutionary ecology also suggests that increasing competition for resources serves as a catalyst for group formation and the development of intensive cultivation practices. According to Boone (1983 : 82), cooperation in groups arises from mutual self interest, and the benefits are often contingent on continued group functioning. In a case where agriculture is the main mode of subsistence, group formation provides more labor, which often allows for more intensive practices and a higher net gain for all members.

However, agriculture also requires a long-term commitment in order to be productive, and if group size grows too large the net gains for each individual will drop and groups will dissolve (Smith 1987 : 209–214). Therefore, areas that can obtain an equilibrium between resource production and population will be the most successful, and thus group size and complexity will vary across space in accordance with the productivity of the environment. In this Fijian case study, fortifications are assumed to be an artifact of group formation, and the most common fort sizes, designs, and distributions across the landscape will be examined to determine the number of group-oriented subsistence strategies that exist in this varying environment.

As a secondary effect of group formation, evolutionary ecology dictates that group size (population density) is also linked to intergroup competition. According to Boone, the size of groups correlates to the intensity of intergroup competition (Boone 1983 : 83). As competition increases, it becomes advantageous to join a large group or to merge two smaller ones, as long as the benefits of group membership ensure a greater net gain than that of smaller group membership. Consequently, the areas that offer the largest amounts of predictable resources will also be inhabited by the largest groups. In the Fiji case, these areas would correspond to the location of the largest forts. The smaller forts should correspond to areas that can produce small yields, are less predictable, or are less fertile.

Finally, evolutionary ecology dictates that the loci of intense intergroup competition for resources can change in accordance with the most valued resource. Times of environmental stress or violent conflict may deplete areas that were once production centers, and competition may be refocused on another variable in the environment, such as access to another cultivar, water, or defensible positions (Cashdan 1992). In regions where warfare and aggression have been endemic for long periods of time, the populations may have resorted to several different subsistence strategies, all of which had varying success across the landscape. This aspect of competition will be examined in detail in this case study. In particular, the presence of natural and constructed defenses in fortifications and their relation to surrounding resources will be analyzed in detail.

In conclusion, evolutionary ecology provides several expectations that can aid in spatial analyses of Fijian sites. These analyses can also provide a window into what evolutionary processes structured prehistory, and how these processes might have contributed to the warlike nature of ancient Fijian society.

CASE STUDY: THE SIGATOKA VALLEY, VITI LEVU, FIJI

The following case study is based upon an extensive data set created by Parry (1987) of the fortifications of the Sigatoka River valley, in southwestern Viti Levu, Fiji (Fig. 1). Using aerial photographs, Parry analyzed approximately 600 km^2 of the river valley, covering both sides of the river from its headwaters to its mouth. Using descriptions of forts provided by Gifford (1951) and Palmer (1967), Parry was able to identify and classify 275 archaeological features in the Sigatoka Valley, and provided descriptions of their morphological, topographic, and inferred functional attributes.

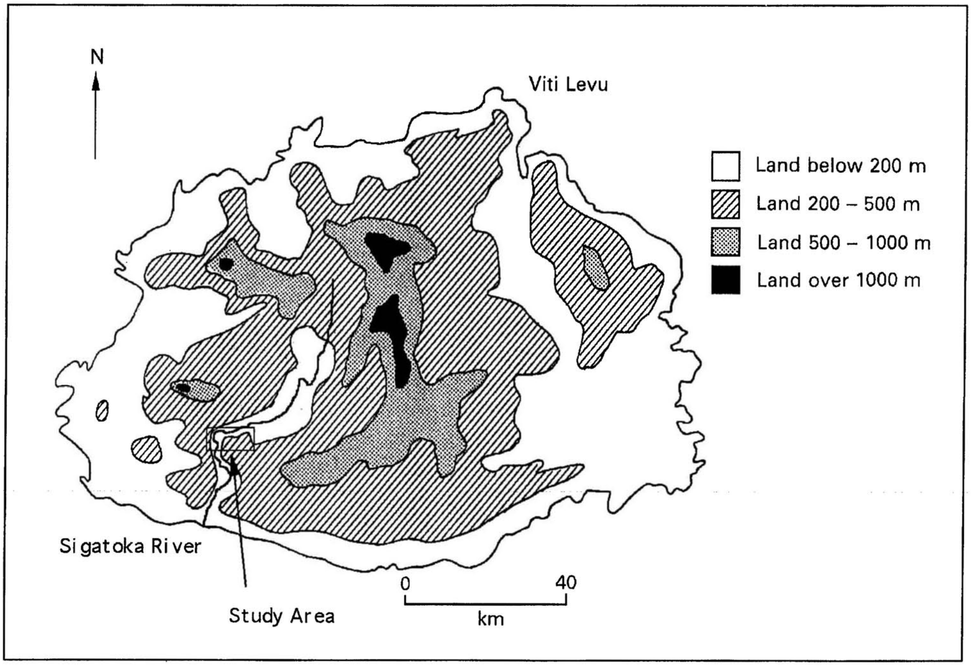

Fig. 1. Map of Viti Levu, Fiji, showing the Sigatoka River and the study area. Adapted from Nunn (1994: 162).

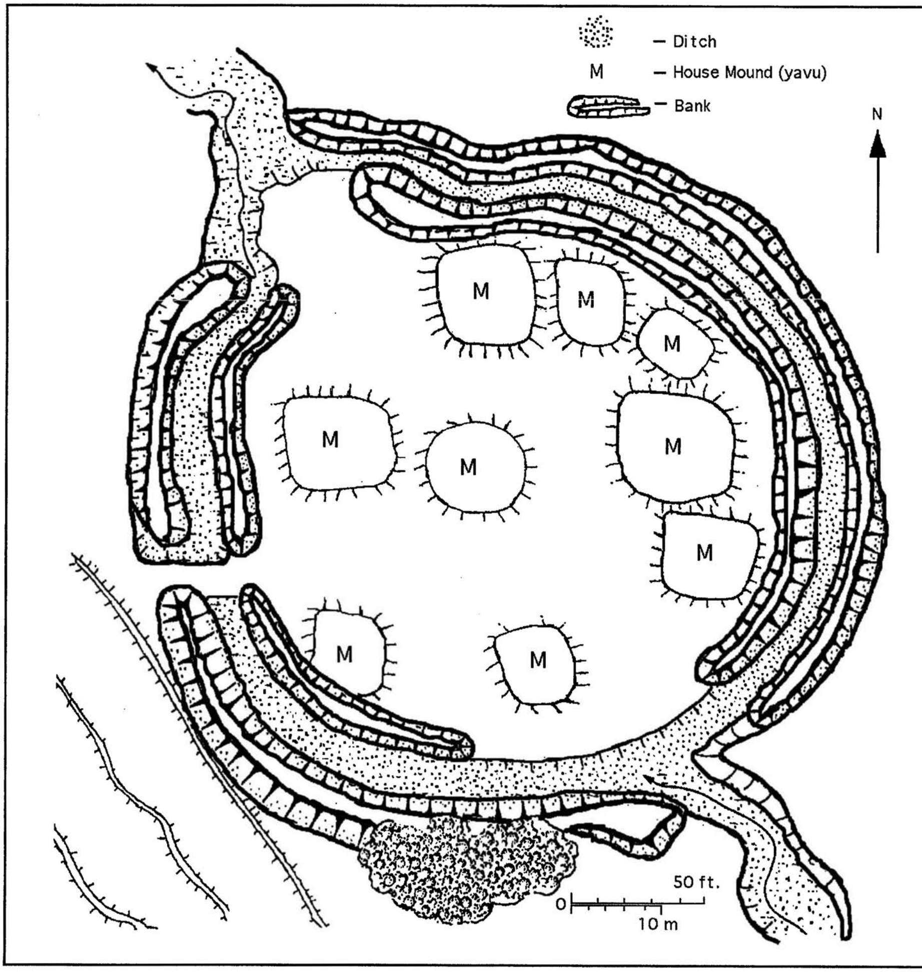

Fig. 2. Site map of ring-ditch fort in Sigatoka Valley, derived from air photo interpretation. Adapted from Parry (1987: Plate 14).

Of the five fortification types that have been defined by the work of Palmer (1967, 1969*a*, 1969*b*, 1971), Parry (1977, 1981, 1987), and Best (1993), two types in particular have received the most attention. These fortifications are known from oral histories and nineteenth-century historic documents as *koro waiwai* (ring-ditch forts) and *koro ni valu* (hill forts) (Parry 1987 : 89). Briefly, ring-ditch forts are characterized by a cluster of house-mounds surrounded by one or more annular ditches and palisades, with access to the habitation area provided by defended causeways (Fig. 2). These forts range in size from 16 to 300 m in diameter, and are usually found on the flat land along the coasts, in the river deltas, and in the level valley bottoms of the interior (Palmer 1969*a*; Parry 1977, 1981). Hill forts consist of clusters of house mounds on the tops of isolated peaks and narrow ridges, which are variably surrounded by lines of ditches, scarps, and palisades (Fig. 3). Forts that are located on hilltops can be quite small (c. 40 m in diameter),

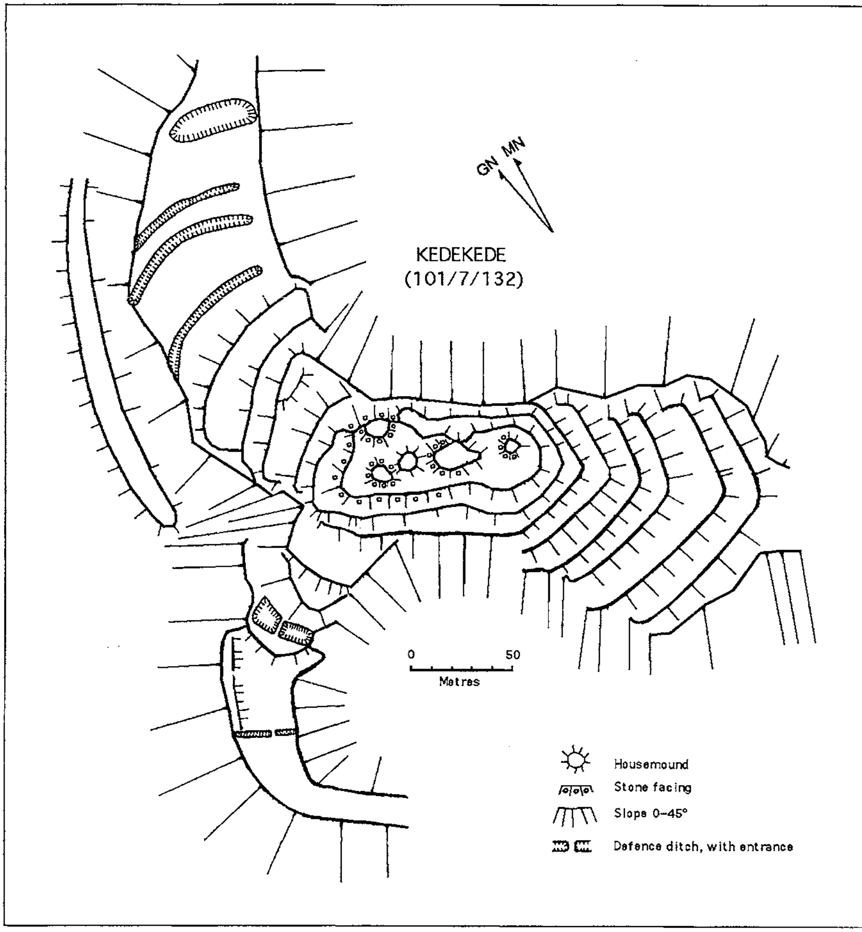

Fig. 3. Site map of hill fort on Lekeba, Lau Islands, Fiji. Adapted from Best (1993 : 402).

but they can also run for extended lengths along ridge tops, and reach up to 300 m in length (Palmer 1969*b*; Parry 1987; Best 1993).

This study focuses on one small portion of the Sigatoka Valley, the Naqalimare region, which is known from oral histories and historic documents as the home of a particularly warlike tribe, the *Kai Qalimare* (Gordon 1879). The boundaries of this region were placed in accordance to historic documents and maps that were drawn during the highland disturbances of 1876. The study area encompasses approximately 98 km^2, and within it Parry documented 48 fortified archaeological features and the remains of 20 agricultural features, consisting of earthen terraces and ponded fields (Fig. 4).

Root-Crop Cultivation in the Naqalimare Region

Fijian ethnohistory and archaeological data indicate that prehistoric populations in the interior subsisted on cultivated taro, yams, and sweet potatoes (Wilkes 1845;

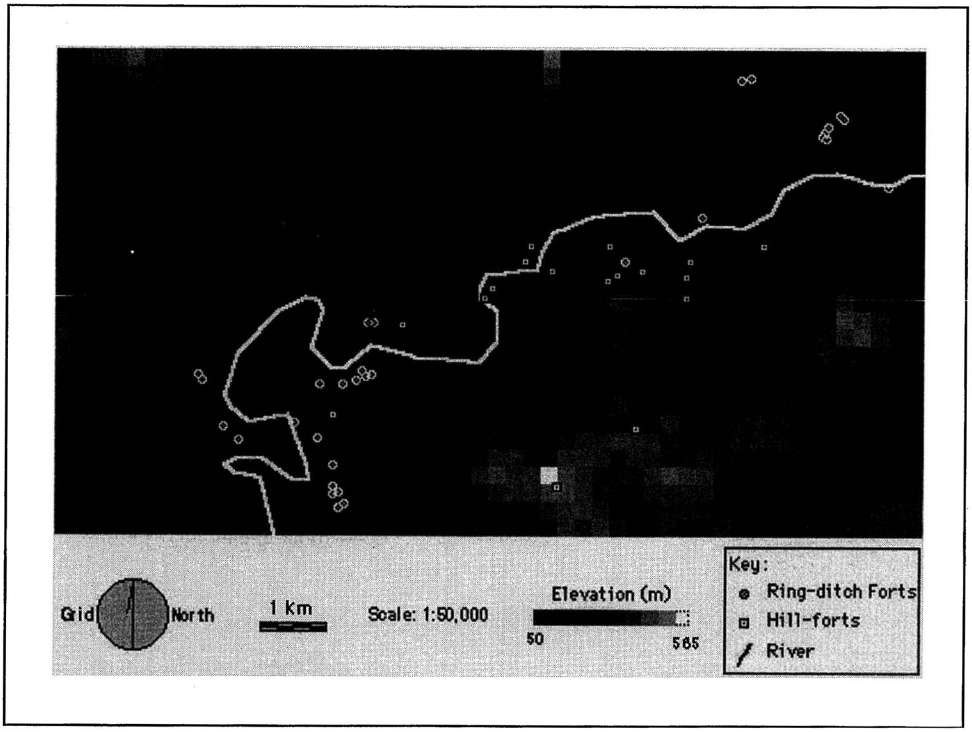

Fig. 4. Rasterized version of the study area, the Naqalimare region of the Sigatoka Valley, Fiji. Image generated with Idrisi GIS software.

Williams 1858; Gordon 1879). Although Lapita-aged remains of taro and yam have yet to be found, most archaeologists advocate that these cultivars were included in an early horticultural-aboricultural subsistence strategy, which developed later into systematized cultivation (Hunt 1981; Kirch 1997; Kirch and Lepofsky 1993). At the time of contact, three species of taro were grown in Fiji: *Colocasia esculenta*, the smaller, finer variety of taro; *Crytosperma chamissonis*, swamp taro; and *Alocasia macrorrhiza*, elephant ear taro. All three types of taro produce an average optimum yield of 7–12 t/ha when planted in fertile soil with a high water retention capacity, thus cultivation is usually dictated by the co-occurrence of these two variables. The required growth period averages 180–210 days, and the corms can be stored for as long as 120 days (Tindall 1983 : 52–56). In relatively flat, well-watered areas, taro was grown in raised beds or ponded fields (*vuci*). In more dry, rugged terrain, diverted streams were used to irrigate beds that ran along rivers, or extended (sometimes with bamboo piping) to feed terraces (*tabawai*) that were cut into the hillsides below (Kuhlken 1994). One of the varieties of taro, *Colocasia esculenta*, was also hardy enough to grow on dry land. This cultivar was usually planted in nonirrigated terraces.

Unlike wetland taro, yams *(Discorea spp.)* prefer a well-drained sandy soil and require no irrigation. Thus, it was usually cultivated on dry, rocky hillsides (sometimes terraced), or in mounds where the ground was level. The required growth period for yams is between 220 and 300 days, and after preparation the tubers can be stored for as long as 120 days. The optimum yields average 20–25 t/ha (Tindall 1983:203–207).

Both taro and yams have high yields, and they are equal to one another in nutritional content; both provide approximately 120 calories per 100 g (Tindall 1983:63, 207). However, the cultivation of taro requires the greatest investment of time and labor, in the construction and tending of terraces, ponds, and irrigation. Taro also requires a high annual rainfall (approximately 2000–2500 mm) with the rains distributed evenly throughout the year. This may have presented a problem for prehistoric taro agriculture in the Sigatoka, since this region experiences a three-month dry season and receives a total annual rainfall of 1700–2000 mm. Thus, subsistence on taro during the dry season may have been risky for prehistoric populations.

Yams are less labor-intensive, and although they require a nine-month growth period, they can easily be planted and then only periodically weeded until harvest time. They can also grow at high as well as low elevations, are well suited to dry conditions, and require only 1000–1500 mm of rainfall for optimum yields. Historic documents from the nineteenth century cite the yam as the main component of the Fijian diet, although taro was still an important crop (Williams 1858:61–62). Although it is unknown exactly if and when dryland taro and yams replaced wetland taro as the main source of subsistence, it seems likely that both of these cultivars contributed to the initial expansion into the interior. Grown as a wetland crop, taro would have been restricted to the valley bottoms and coastal flats, thus limiting settlement to these areas. Yams, which are better adapted to dry, rugged terrain, would have allowed for cultivation of lands that were more mountainous and less productive, thus opening up large parts of the Sigatoka Valley, and ultimately the highland interior, to settlement. This may explain why competition was so extensive in Fiji—the rugged environment provided many niches for population competition.

The following analyses focus on the spatial distribution of the lands that could produce these two resources and the nature of the forts associated with them. Because the GIS computer program allows for digital overlays of archaeological and environmental variables, GIS analyses are particularly well suited to these types of spatial studies. GIS analyses result in the generation of new data and insights into the relationships between humans and the natural environment.

GIS ANALYSIS OF AGRICULTURAL RESOURCES IN THE NAQALIMARE REGION

Taking the cultivation requirements into account, the variables of soil type, access to water, slope, and land form are the determining factors for the suitability of land for cultivation. The variables of slope and soil type were entered into the GIS to produce three predictive images: one that overlays steep slopes (15–30°) and sandy deposits, one that overlays steep slopes and clay deposits, and one that overlays relatively level ground (0–15°) with clay and alluvial deposits. These images were used to predict where terrace and ponded cultivation of yam and taro could have occurred. These images were then incorporated into the known locations of fortifications and agricultural features in the Naqalimare region, which allowed for analyses of the distribution of forts by their size, proximity to known cultivated areas, and the overall abundance of arable land. These data are summarized in Tables 1 and 2.

Fort Distribution vs. Suitability of Land to Cultivation

The study area itself comprises 87.5 km^2, of which 39 percent (40.3 km^2) is suitable for dryland cultivation and 25 percent (26.5 km^2) is suitable for wetland cultivation. The remaining land is either too steep or rocky to be cultivated. In this analysis, access to arable land was determined by measuring the size and proximity of the closest land plots to each fort. As indicated by Tables 1 and 2, the forts were divided arbitrarily into three subsets according to the amount of arable wetland closest to each fort, and the forts within these subsets were then ordered according to size. This analysis reveals that the majority of the ring-ditch forts are distributed in locations that afford them access to large yields of wetland cultivars and low yields of dryland cultivars. The remainder of the ring-ditch forts have access to moderate wetland yields, and also supplement themselves with dryland yields.

In the first subset, 14 (45 percent) of the ring-ditch forts occur on or close to (within 0.5 km) 75,000 m^2 of land that is suitable for the cultivation of wetland taro (Table 1). The land consists of well-watered alluvial deposits in the bottoms and foothills of the Sigatoka Valley. Of these forts, the more moderate sizes (size classes 3 and 2) also have access to small plots suitable for dryland cultivation and are within 1 km of terrace and pond features. On average, the ring-ditch forts in the first subset could receive 96 percent of their harvests from land suited to wetland cultivation.

In the second subset, nine (29 percent) of the ring-ditch forts are within 0.5 km of taro-suited plots, which average 4442 m^2. Many of these forts (especially the smallest size classes) are located directly on these plots and also have access to land suited to dryland cultivation. On average, the ring-ditch forts in the second subset could receive 76 percent of their harvests from land suited to wetland cultivation.

In the third subset, eight (25 percent) ring-ditch forts are associated with plots of land suited to wetland cultivation, averaging 2188 m^2. All of the forts in this subset are also associated with plots of land suited to dryland cultivation, and on average these forts could receive 55 percent of their harvests from land suited to dryland cultivation. These dryland plots average 2734 m^2.

In contrast to the ring-ditch forts, the hill forts demonstrate several different subsistence strategies. A minority of the hill forts have access to large and moderate yields of wetland cultivars as well as low yields of dryland cultivars. However, the vast majority subsist on moderate yields of dryland cultivars.

As indicated by Table 2, one hill fort constitutes the first subset. This fort is associated with the 75,000 m^2 tract of land suited to growing taro, and/or is also situated on a small plot of land suited to dryland cultivation. This hill fort (Fort Matanavu) is also the largest in the study, which provides evidence for increased group size in areas of substantial resources.

Two (12 percent) hill forts constitute the second subset. These forts have access to moderate-sized wetland resources, averaging 6875 m^2, and also have access to

Table 1. Summary of Agricultural Data for the Ring-Ditch Forts

FORT NAME	SIZE CLASS[a]	SOIL TYPE	SLOPE	PROX. TO TERRACES (km)	PROX. TO PONDS (-km)	PROX. TO WETLAND AG. (km)	AREA (m^2)	PROX. TO DRYLAND AG. (km)	AREA (m^2)
Subset 1									
Navalili	8	Alluv. clay	0–5°	2.75	1.75	0	75000	0.5	2500
Nabuavat	3	Alluv. clay	0–5°	0.85	1.75	0.25	75000	0.25	5000
Sig. 19	3	Alluv. clay	0–5°	0.6	0.35	0.5	75000	0.5	2500
Sig. 21	3	Alluv. clay	0–5°	0.6	0.35	0.5	75000	0.5	2500
Sig. 20	2	Alluv. clay	0–5°	0.6	0.35	0.5	75000	0.25	5000
Namoli	2	Alluv. clay	0–5°	0.6	0.35	0.5	75000	0.25	5000
Navak	2	Nigr. sandy-clay	0–5°	1.75	1.75	0.5	75000	0	3750
Tubintu	2	Alluv. clay	0–5°	0.5	0.5	0.25	75000	0.25	2500
Nakeli	2	Lat. sandy-clay	0–5°	0.6	1.1	0.5	75000	1	1875
Nalotawa	2	Nigr. sandy-clay	0–5°	0.1	0.25	0.25	75000	0	625
Niabarea	2	Nigr. sandy-clay	0–5°	0.1	0.5	0.25	75000	0.5	625
Sig. 23	1	Gley sandy-clay	0–5°	0.5	0.5	0.25	75000	0.25	3750
Sig. 18	1	Lat. sandy-clay	0–5°	0.7	1.1	0.25	75000	1	2500
Sig. 24	1	Alluv. clay	0–5°	1.75	1	0.25	75000	0.25	1250
Averages of subset 1				0.85	0.82	0.33	75000	0.39	2813
Subset 2									
Korokula	4	Alluv. clay	0–5°	1	1.25	0.25	3725	0.25	625
Namaliwa	4	Alluv. clay	5–10°	1.75	1.25	0.25	3125	0	625
Laquara	2	Alluv. clay	5–10°	1.1	0.3	0	5000	0.25	1250
Sig. 1	2	Nigr. sandy-clay	5–10°	0.2	0.5	0.25	4375	0.25	2500
Sig. 9	1	Gley sandy-clay	5–10°	0.35	0.6	0.5	6250	0.25	2500
Sig. 5	1	Alluv. clay	5–10°	1.8	0.5	0	4375	0.25	1250
Sig. 3	1	Alluv. clay	5–10°	1.8	0.5	0	4375	0.25	1250
Sig. 2	1	Alluv. clay	5–10°	0.5	0.5	0	4375	0.25	1250
Sig. 4	1	Alluv. clay	5–10°	1.8	0.5	0	4375	0.25	1250
Averages of subset 2				1.1	0.65	0.1	4442	0.22	1389

Subset 3									
Mavua	3	Nigr. sandy-clay	0–5°	2	1.75	1	1875	0.25	3750
Sig. 28	2	Nigr. sandy-clay	0–5°	2	1.75	0.5	1875	0.25	3750
Navala	2	Nigr. sandy-clay	0–5°	1	1.25	0.25	1250	0	2500
Rewasali	1	Alluv. clay	5–10°	0.5	0.35	0.25	3125	0.25	1250
Togovere	1	Alluv. clay	5–10°	0.5	0.35	0.5	3125	0	1250
Sig. 27	1	Nigr. sandy-clay	0–5°	1.75	1.75	0.5	2500	0.5	2500
Sig. 26	1	Nigr. sandy-clay	0–5°	1.75	1.75	0.5	2500	0	2500
Sig. 11	1	Nigr. stony-clay	0–5°	0.5	2.1	1	1250	0.5	4375
Averages of subset 3				1.23	1.4	0.56	2188	0.22	2734
Averages of totals				1.02	0.93	0.33	35725	0.29	2379

[a] Size classes defined by Parry. 1 = 48 m; 2 = 48–80 m; 3 = 88–112 m; 4 = 112–144 m; 5 = 144–176 m; 6 = 176–208 m; 7 = 208–240 m; 8 = 240–272 m; 9 = >272 m

TABLE 2. SUMMARY OF AGRICULTURAL DATA FOR THE HILL FORTS

FORT NAME	SIZE CLASS	SOIL TYPE	SLOPE	PROX. TO TERRACES (km)	PROX. TO PONDS (-km)	PROX. TO WETLAND AG. (km)	AREA (m^2)	PROX. TO DRYLAND AG. (km)	AREA (m^2)
Subset 1									
Matanavu	4	Gley sandy-clay	20–25°	0.5	3	0.1	75000	0	1875
Averages of subset 1				0.5	3	0.1	75000	0	1875
Subset 2									
Korosam	2	Gley sandy-clay	10–15°	1.75	0.5	0.5	7500	0.25	625
Sig. 17	1	Latosol. clay	20–25°	0.5	3.85	0.25	6250	1	2500
Averages of subset 2				1.1	2.2	0.38	6875	0.63	1563
Subset 3									
Koroivat	2	Nigr. stony-clay	10–15°	2.75	1.6	0.1	1250	0.5	3125
Sig. 10	2	Nigr. stony-clay	15–20°	0.25	2.5	1	1250	1	5000
Nabociwa	2	Nigr. stony-clay	10–15°	0.75	2.25	1	1250	1	5000
Tawadi	2	Nigr. stony-clay	10–15°	0.75	2.75	0.25	625	0.75	5000
Quorquoro	2	Nigr. stony-clay	10–15°	1	1	0.25	625	0.25	625
Sig. 14	1	Nigr. stony-clay	15–20°	1	2.5	1	1250	1	3750
Sig. 25	1	Nigr. stony-clay	20–25°	0.3	0.5	0.5	1250	0.25	3125
Koroira	1	Nigr. stony-clay	15–20°	0.25	3.5	0.5	1250	0.5	2500
Bukutia	1	Nigr. stony-clay	10–15°	1.75	5	0.25	1250	0.5	6250
Sig. 15	1	Nigr. stony-clay	20–25°	0.5	4	0	1250	0.25	1250
Wakuku	1	Nigr. stony-clay	10–15°	0.75	2.25	0.75	625	0.75	3750
Sig. 16	1	Nigr. stony-clay	20–25°	0.75	3.75	0	625	0.25	2500
Sig. 29	1	Nigr. stony-clay	20–25°	0.5	3	0	625	0.25	2500
Korovusu	1	Nigr. stony-clay	10–15°	1	1.75	0.75	625	0.25	625
Averages of subset 3				0.88	2.6	0.45	982	0.54	3214
Averages of totals				0.88	2.6	0.42	6029	0.58	2941

small plots of land suited to dryland cultivation, averaging 1563 m^2. On average, wetland resources could account for 81 percent of the harvests for the forts in this subset.

Thirteen (82 percent) hill forts fall into the third subset. On average, dryland resources could account for 76 percent of the harvests. These forts have access to almost twice the amount of dryland resources as the other forts, averaging 3214 m^2. In addition, the majority of the larger size class of forts (size class 2) have access to plots that range from 3125 to 5000 m^2, which is well above the average for the subset.

Comparison of Findings with Parry's Interpretations

The results of the analyses listed above are largely congruent with Parry's original findings, but they do provide a number of new perspectives. In the case of the ring-ditch forts, he noted that they occur in a nonrandom pattern across the series of clays that constitute the river terraces of the valley bottom. The GIS analysis revealed a more detailed account of that correlation, and the inclusion of slope did not change the results. According to Parry, this settlement pattern is indicative of the importance of the wetland taro subsistence base: settlements occur in close proximity to gardens located on the valley floor and hillsides. This serves to minimize the transit time and maximize the time for food production (Parry 1987 : 117). Parry also advocates that the clustering of small and larger ring-ditch forts attests to the development of local hegemonies within the areas of greatest agricultural production (Parry 1987 : 102). This pattern is identical to territorial strategies outlined by evolutionary ecology: dense and predictable resources will encourage increased group size and the formation of social hierarchies.

Despite their location in prime yam growing territory, Parry hypothesizes that the hill fort tradition is the result of the desire to retain control over dense and predictable wetland resources in the valley bottom. Fortifying a settlement served to preserve the populace and also retain possession of the land:

> In many parts of the Sigatoka it was clear that the inhabitants were unable to take full advantage of the best soils or the best settlement sites because of the ever-present danger of attack. In this situation, defensible topographic features were sought out and a strongly fortified position in close proximity to a resource base became the desideratum. An alternative strategy, the combination of valley floor settlement and mountain citadel, was also followed. (Parry 1987 : 118)

The GIS-based analyses above lend support to this view, especially when the average yields of the hill forts are compared to the average yields of the ring-ditch forts; the valley floor was far more productive.

To further examine the hill fort/ring-ditch fort dichotomy, the following set of analyses will focus on another aspect of settlement: the ability of a location to provide defense and/or resources. Parry's study concurs with evolutionary ecology in suggesting that settlement patterns are a product of the environment, and it follows that choices made concerning subsistence and defense can be discerned more clearly through a study of forts and topography. These data are indeed attainable with GIS, and also lend themselves to a more detailed study of evolving subsistence systems.

NATURAL VS. CONSTRUCTED DEFENSES

This study utilizes a classification of archaeological features designed by Parry (1987 : 60). Although in many circumstances it is difficult to quantify features because they are essentially continuous and flow into one another, a dimensional classification that focuses on discrete features (e.g., a ditch, wall, pit, etc.) allows for the defensive capabilities of fortifications to be quantified in a systematic fashion. This is particularly important when these features are compared to their context, in which case they can indicate how groups adapted to or modified their environment. For example, gentle slopes that were modified with a large number of defensive features are indicative of the importance of retaining a settlement at that location. A settlement with a much smaller number of defenses indicates that the location either did not require modification, or it was not worthy of a high degree of protection. Contrariwise, this system is limited in that it cannot accurately measure the quality of defense—it is impossible to know if walls were better defensive features than ditches, or if one feature could do the work of two. The sheer number of a certain kind or pattern of defense, however, may indirectly indicate quality. Problems that have arisen from this aspect of the classification will be discussed in more detail in a later section.

Parry's classification system characterized each fort using 30 discrete dimensions. Each fort was thus coded systematically according to its construction attributes, e.g., size and shape, and also the type and number of features. Parry also described the environment surrounding each fort, coding the landforms on which they were constructed. The dichotomy between these two types of defenses, natural and constructed, will play an important role in the analyses that follow.

Briefly, constructed defenses are defined as anything that is artificially constructed, e.g., walls, ditches, banks, palisades, or terraces. These attributes were identified and defined by Parry, and will be analyzed according to their occurrence, and abundance. Natural defenses, such as visibility and accessibility, are quantitative attributes when identified by GIS applications. Differences in visibility and accessibility are the product of the rugged terrain of Fiji, and they provide context for the additional cultural features that were constructed for defensive purposes. Prior to the advent of GIS applications, these defensive features were either ignored or considered to be unquantifiable. That this technology is now available for the study of the effects of topography is an immense advantage to the paleogeographer. In essence, visibility and accessibility are first order variables for fortifications, since they determine how "safe" a particular location is on the landscape.

In this study, visibility refers to the generation of viewsheds, which are graphic displays that represent all areas within the visual range of any particular point on the landscape. Although visibility has not been analyzed in previous studies of Fijian forts, it is indeed an important factor worldwide in the selection of locations for construction and the placement of defensive features (e.g., Madry and Rakos 1996 : 104; Ruggles and Medyckyj-Scott 1996 : 127). The generation of cost surfaces are another GIS addition, and in this study they are used to represent fort accessibility. This analytic device measures the amount of energy spent when moving across an inclined surface. These data are indicative of the accessibility of fortifications, and in some cases the environmental factors that selected for certain defensive attributes.

NATURAL VS. CONSTRUCTED DEFENSES IN THE FORTIFICATIONS OF THE NAQALIMARE REGION

The image in Figure 5 is a representation of the topography of the Naqalimare region of the Sigatoka Valley. The map of the study area mentioned previously (Fig. 4) is a raster version of this topography, in which points on the landscape are reduced to x, y, and z coordinates, and was used to calculate viewsheds and cost surfaces for all the sites in the study area. The results of these analyses have been summarized in Tables 3 and 4, and a synthesis of these data sets reveals several behavioral strategies that utilize site selection and subsequent alteration of the landscape.

Hill Forts

As shown in Figure 4, the hill forts occur in loose clusters across the study area, occurring at elevations between 43 and 565 m above sea level. Although 80 percent of the land in the Sigatoka is at an elevation higher than 400 m, only one (6 percent) of the hill-forts occurs above that elevation. The remaining forts are scattered evenly across the elevations: six (35 percent) occur between 400 and

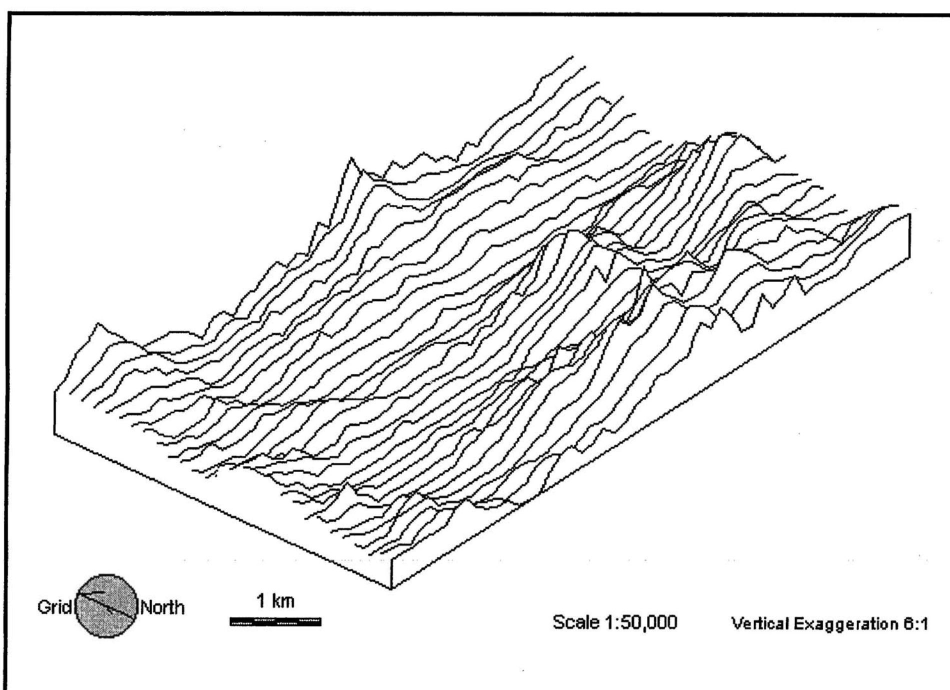

Fig. 5. Topography of the Naqalimare region. Image generated with Idrisi GIS software.

Table 3. Summary of Natural and Constructed Defenses for the Hill Forts

SUBSET	FORT NAME	SIZE CLASS	ELEVATION (m)	NUMBER OF FORTS VISIBLE	PERCENTAGE	NO. OF CONSTRUCTED DEFENSES	TYPE	SLOPE	COST INDEX
1	Matanavu	4	104.5	13	27	0		20–25°	5
2	Sig. 17	1	66.8	16	33	2	scarp	20–25°	5
	Korosam	2	182.1	15	31	0		10–15°	3
3	Sig. 29	1	103	15	31	0		20–25°	5
	Sig. 25	1	112.5	12	25	3	scarp	20–25°	5
	Sig. 15	1	53.4	6	13	0		20–25°	5
	Sig. 16	1	43.3	5	10	1	ditch	20–25°	5
	Sig. 10	2	282.2	28	58	0		15–20°	4
	Sig. 14	1	121.6	10	20	3	scarp	15–20°	4
	Koroira	1	84.1	7	15	3	scarp, ditch	15–20°	4
	Nabociwa	2	356	29	60	0		10–15°	3
	Korovusu	1	268.2	17	35	0		10–15°	3
	Wakuku	1	218.2	14	29	1	scarp	10–15°	3
	Koroivat	2	384.5	12	25	3	ditch, scarp	10–15°	3
	Tawadi	2	179.4	11	22	0		10–15°	3
	Quorquoro	2	268.8	10	20	0		10–15°	3
	Bukutia	1	565	5	10	1	ditch	10–15°	3

Table 4. Summary of Natural and Constructed Defenses for the Ring-Ditch Forts

SUBSET	FORT NAME	SIZE CLASS	ELEVATION (m)	NUMBER OF FORTS VISIBLE	PERCENTAGE	NUMBER OF CONSTRUCTED DEFENSES	TYPE	SLOPE	COST INDEX
1	Tubintu	2	38.1	15	31	0		0–5°	1
	Sig. 23	1	35.6	14	29	0		0–5°	1
	Sig. 18	1	66.7	14	29	0		0–5°	1
	Namoli	2	48.7	13	27	0		0–5°	1
	Sig. 21	3	48.7	13	27	0		0–5°	1
	Sig. 19	3	52.1	13	27	0		0–5°	1
	Sig. 24	1	34.7	13	27	0		0–5°	1
	Navalili	8	34.7	13	27	0		0–5°	1
	Nalotawa	2	65.2	12	25	0		0–5°	1
	Niabarea	2	68.5	12	25	1	2nd ditch	0–5°	1
	Sig. 20	2	62.1	9	19	0		0–5°	1
	Nabuavat	3	35.3	8	16	0		0–5°	1
	Nakeli	2	38.7	8	16	0		0–5°	1
	Navak	2	77.1	7	14	0		0–5°	1
2	Sig. 2	1	147.3	17	35	0		5–10°	2
	Sig. 4	1	147.3	17	35	0		5–10°	2
	Sig. 5	1	124.6	15	31	0		5–10°	2
	Sig. 3	1	124.6	15	31	0		5–10°	2
	Namaliwa	4	131.7	10	21	1	2nd ditch	5–10°	2
	Sig. 9	1	70.4	10	21	0		5–10°	2
	Sig. 1	2	131.7	10	21	1	2nd ditch	5–10°	2
	Laquara	2	40.5	9	19	0		5–10°	2
	Korokula	4	41.2	11	23	0		0–5°	1
3	Sig. 11	1	282	32	66	1	ditch	5–10°	2
	Rewasali	1	133.8	6	13	0		5–10°	2
	Togovere	1	133.1	1	1	0		5–10°	2
	Sig. 28	2	152.1	8	16	0		0–5°	1
	Mavua	3	152.1	8	16	0		0–5°	1
	Sig. 26	1	115.5	7	14	0		0–5°	1
	Sig. 27	1	115.5	6	13	0		0–5°	1
	Navala	2	76.2	4	8	0		0–5°	1

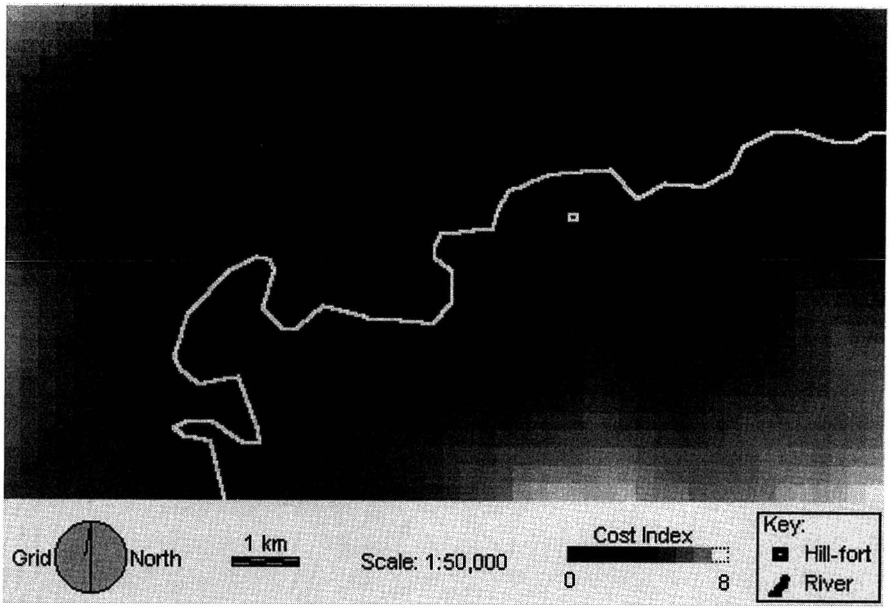

Fig. 6. Cost surface generated for fort Sig. 29, indicated by the white square with the dark center located at the center of the image. Increasing cost is indicated by the scale in the legend. Image generated with Idrisi GIS software.

200 m, six (35 percent) occur between 100 and 200 m, and four (23 percent) occur below 100 m.

Tables 3 and 4 are structured according to the subsets determined from the preliminary agricultural analysis. These subsets are arranged in descending order according to their cost index and the percentage of forts visible in each viewshed. The results of these analyses reveal how groups incorporate other variables in their subsistence strategies, namely defense, as a part of their repertoire of survival skills. The following sections will discuss these strategies in detail for both the hill and ring-ditch forts.

The cost indices listed in Table 3 are the result of cost surfaces generated for the hill forts in the study area. In each case, the rasterized version of the topography of the Naqalimare region was transformed into a friction surface, which indicated by graded colors the cost of approaching a single point from any direction. This cost, which corresponds to steepness of slope, was thus indicated at an integer scale. The hill fort shown in Figure 6 serves as an example of this analysis. The hill fort (fort Sig. 29) lacks artificially constructed defenses. The light shaded areas indicate the slopes that inflict the least cost to move across, and the dark shaded areas indicate the slopes that inflict the most. The slope of the land surrounding each site within a 1 km radius was recorded, and the largest fraction was used to create a cost index: forts surrounded by a slope between 20–25° were given the value of five, those surrounded by 15–20° were given a value of four, etc.

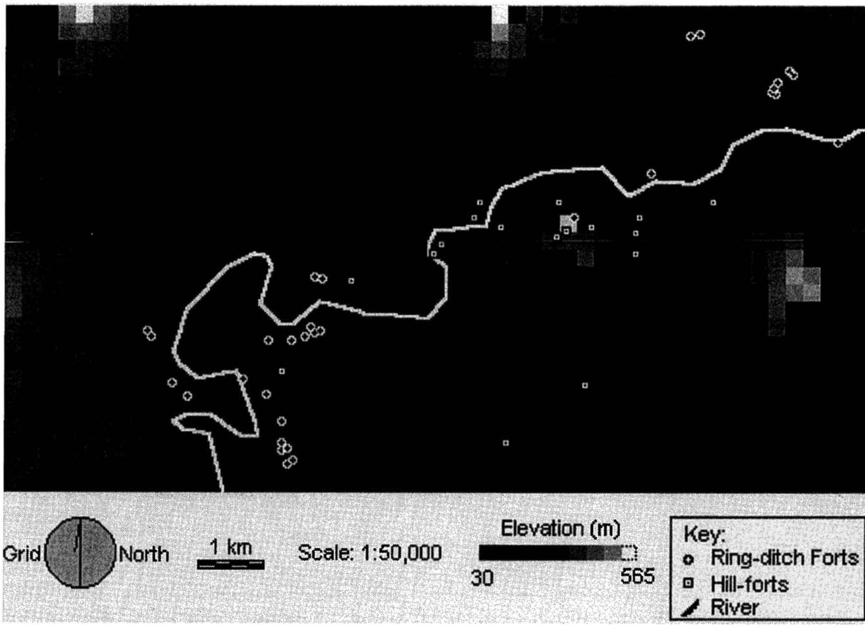

Fig. 7. Viewshed generated for fort Sig. 10, indicated by the hill fort symbol on the white square located to the right of the center of the image. Other forts within view of fort Sig. 10 are indicated by their location on the grayscale topography. Image generated with Idrisi GIS software.

As Table 3 demonstrates, ordering the hill forts according to their cost indices reveals the defensive-based patterns that occur across the three subsets. For the third subset, which consists of the 82 percent of the hill forts that have access to moderate yields of dryland crops and low yields of wetland, the cost indices are spread fairly evenly. This indicates that slopes between 10° and 25° can contain land plots of various sizes, and being located on steep land does not necessarily reduce the amount of agricultural resources. Therefore, despite being located in a varied, rugged terrain, hill forts could expect a moderate dryland yield at most locations. This also indicates that fort location in rugged areas was not based upon maximizing dryland yields.

A comparison of the cost indices and the presence/absence of constructed defenses yielded a moderate correlation between steepness of slope and constructed defenses. Fifty percent of the cost index five forts, 66 percent of the cost index four forts, and 38 percent of the cost index three forts contained constructed defenses. These data accord with statements made by Elsdon Best in his monograph on fortifications of New Zealand. He hypothesized that the location of defensive sites was of critical importance, and the construction of defenses was designed to repel intruders when the natural topography was insufficient (Best 1975 : 21). Although a strong connection between theses two variables does not exist in the sample, the correlation does not appear weak enough to be nonexistent. In addition, the average number of artificially constructed features are higher among the lower cost indices, which indicates that in a larger study that involved correlation statistics, a negative correlation could be revealed.

However, an analysis of the frequencies of constructed defenses and the size of the viewsheds indicated the presence of a negative correlation. In the third subset of the hill forts, 50 percent of the forts have constructed defenses, and the majority of these have multiple features. The majority of these forts also have moderate sized viewsheds, i.e., they have views of 15–25 percent of the other forts in the sample (the largest viewshed in the sample contains 60 percent of the other forts). If visibility is considered as an aspect of defense, then these forts with moderate natural defenses made up for their insufficiencies by constructing additional defensive features. In addition, the forts with large viewsheds demonstrate a reciprocal relationship in that they lack additional constructed defenses. For example, the hill fort indicated in Figure 7 (Sig. 10) lacks large numbers of constructed defenses, but has an extensive view of the valley. The other hill and ring-ditch forts that fall within its viewshed are indicated by symbols on the grayscale topography. Those sites that are not in view are indicated by the black areas. Because of its location on the landscape, this fort has 28 (58 percent) of the other forts in view at all times, thus reducing the need for additional constructed defenses.

Despite being a small fraction of the total hill forts in the sample, the forts in the first and second subsets also provide revealing insights into subsistence and defense strategies. The single fort in the first subset, Fort Matanavu, has a cost index of five, indicating it was located in a very inaccessible location. This fort also lacks additional constructed defenses, perhaps due to the fact that the 25° slopes served as an effective deterrent to would-be attackers. However, when the size of this fort is compared to its location on the landscape, its focus on agricultural production becomes apparent. Despite being constructed on a hill, this size class four fort has access to the largest tract of arable wetland in the study. Similarly, the two hill forts in the second subset have a similar wetland focus, although they are smaller and have a more intensified defense strategy.

In conclusion, the natural and constructed defenses of the hill forts in the sample indicate two different strategies of subsistence and defense. The majority of the hill forts sacrifice agricultural production for defense, and are located in inaccessible locations with commanding views of the countryside. However, a minority of the hill forts are located in places with more wetland resources, and these forts are placed strategically on hilltops that are naturally and artificially defended. Despite being a small part of the sample, hill forts like Matanavu indicate by their size that this strategy of defended production was a successful, but not dominant, one.

Ring-Ditch Forts

Despite being more numerous and more widely distributed across Fiji, ring-ditch forts have generated less interest than their montane relatives (with the notable exception being Parry's monumental studies of the Rewa and Navua deltas, published in 1977 and 1981). Like the hill forts of the Naqalimare region, an analysis of the natural and constructed defensive attributes in the ring-ditch fort sample revealed surprising correlations between subsistence and defense. However, these correlations also reveal that the majority of the ring-ditch forts represent a more specified subsistence strategy, that of agricultural production. The defensive analysis of these forts was identical to that of the hill forts, and therefore only a summary of the findings will be presented (Table 4).

Forty-five percent of the ring-ditch forts belong to the first subset, and all of these forts are located in places that give them a cost index of one. This is not surprising, since the preliminary agricultural analysis revealed that these forts are located on the rich alluvial plain that constitutes the bottom of the Sigatoka Valley. Despite their low cost indices, these forts retain moderately sized viewsheds that extend up and down the valley.

The ring-ditch forts of the second subset retain higher cost indices, and they also have moderate sized viewsheds. However, these sites do not have access to the 75,000 m^2 tract of arable wetland, but rather are associated with much smaller wetland and dryland plots. These forts also occur at higher elevations, and have a higher frequency of constructed defenses. The third subset reveals a similar correlation, although there is more emphasis on access to moderate levels of dryland and wetland cultivation in a rugged environment. This is further indicated by the higher elevations and the more even spread among the cost indices.

Viewed as a group, the relative lack of additional defensive features (excluding the single ring that typifies a ring-ditch fort) is quite noticeable, and it contrasts with the correlations revealed by the hill forts. However, the additional constructed defenses that are present in the ring-ditch sample also indicate a pattern: ring-ditch forts located in areas that produce moderate yields of wetland resources also invest in additional constructed defenses. Perhaps the ring-ditch forts also lend credence to the discussion earlier in this section concerning the qualitative aspects of defensive features. A single ring-ditch component is a continuous feature—it surrounds the entire fort and is an effective deterrent from any direction. Thus it seems likely that ring-ditch forts, even ones with a single ring-ditch, were well-armed in this fashion. Additionally, the success of these fort types also hints at another qualitative aspect of defense: the fighting strength of the inhabitants. Although this is almost impossible to measure archaeologically, undoubtedly it had an effect in prehistoric times.

The following section will examine the results of this study, and outline the behavioral strategies revealed by subsistence and defensive correlations. These strategies will then be compared to evolutionary ecological premises detailed in the introduction of this study.

FORTIFICATIONS OF THE NAQALIMARE REGION: A SUMMARY OF FINDINGS

The incorporation of the previous two analyses with the initial agricultural study provides a detailed view of the prehistoric fortifications of the Naqalimare region. As a result, five general statements can be made.

First, forts represent one of the three following strategies: (1) a production strategy, which entails the exclusive use of large tracts of arable land that could support a large population, with defense provided by the artificially constructed fort and possibly the inhabitants; (2) a defended production strategy, which entails the defense of small plots of arable land from a naturally defensible position that may have been improved with artificially constructed features; and (3) a defense strategy, which entails the defense of a population from a naturally and artificially fortified position, with agricultural production restricted to low or survival levels only.

Second, when compared to the entire fortification sample, the majority of hill forts follow a defense strategy that sacrifices access to the best agricultural land (wetland and dry) in order to be located in places that are defensible. At these locations, visibility and accessibility were of premier importance. Surprisingly, one of the hill forts practiced a production strategy, and had access to large yields of wetland and dryland cultivars. A small number of hill forts also practiced a defended production strategy, and utilized defensive locations to gain moderate yields of wetland and dryland resources. These results indicate that the hill fort could serve in a variety of strategies, and it was an adaptable design. This also accords with the premises that group size varies according to the productivity of the environment, and that the focus of subsistence can be on a variety of resources. Additionally, these data indicate that human groups are not limited entirely by their environment, but can develop strategies that will allow them to be competitive in a variety of situations.

Third, the distribution of the smaller size classes among the hill-forts correlates with the distribution of low to moderate yields of dryland crops. This suggests that large populations could not have been sustained for long periods of time in the uplands, and that hill forts may have served as mountain strongholds that were maintained for times of great civil unrest, or were temporary forts that were constructed by retreating or fleeing groups. This is largely congruent with Parry's conclusions, and also with ethnohistoric data gathered from the Sigatoka Valley.

Fourth, the majority of ring-ditch forts follow a production strategy by sacrificing natural defensive locations to remain on the rich wetland soils of the valley bottom. These forts lack large numbers of constructed and natural defenses, but their prolific number in the sample indicates that this was a successful strategy. Despite the weak levels of constructed and natural defenses that typify this group, these sites must have been successful at defending themselves, either with a single ring-ditch or with a large defending population that could develop in areas with a high carrying capacity. The more moderately defended ring-ditch forts were not located in the areas of highest yield, which is indicative of their opting for a defended production strategy that afforded small yields and a protective location for a smaller population.

Fifth, the larger sized forts, including ring-ditch and hill forts, were located in areas that offered the most dense and favored predictable resources, and these sites also lacked large numbers of natural and constructed defenses. As noted by Parry and several evolutionary ecologists, large forts reflect the development of relatively large social groups, which would have been possible only in the most productive areas (Boone 1983 : 83; Rogers 1992 : 387; Parry 1987 : 102). These large groups would have grown and incorporated smaller, neighboring groups, thus reducing the number of competitors and decreasing the need for artificial or natural defenses for the fortification itself.

CONCLUSION

This study demonstrates that an evolutionary ecological perspective coupled with a study of landscape reveals the costs and benefits of competition and warfare, and also of the evolution of subsistence strategies and social hierarchies. In particular, evolutionary ecological analyses suggest that landscapes can provide groups with a suite of strategies for competing for varied resources. Archaeological studies of settlement patterns usually focus on the location of resources related to subsistence. However, defense is also a necessary resource in situations of chronic aggression, and knowledge of the defensive attributes of landscapes is essential to understanding the prehistory of a region like Fiji.

Evolutionary ecology is also indicative of the historical processes of change in Fijian society. For example, the segregation of hill and ring-ditch forts and the variation in design, location, and level of subsistence indicate a long history of competition in the region. These patterns are the result of centuries of interaction, and they track the development of groups and competitive strategies. Unfortunately, this study was unable to incorporate temporal data for the forts in the sample, and it is certain that the fortifications in this study were not all contemporaneous. However, work is underway to develop a chronology for the Sigatoka Valley (Hunt et al. forthcoming) and hopefully this research will yield data that can further develop this GIS study.

When large-scale warfare began in Fiji remains unknown, although progress is slowly being made toward discerning this aspect of Fijian prehistory. Future research in Fiji should focus on the expansion of populations into interior areas of the larger islands, and these studies should also take into account the impact of the landscape on human settlement and the patterns that result from competition for critical resources. In particular, regions that could have produced large agricultural yields will likely reflect similar sequences of inter-group population growth, competition, and warfare.

In conclusion, GIS analyses have demonstrated that the distribution of fortifications across the landscape and their proximity to natural resources can only inform on a few of the factors that determined prehistoric settlement patterns. The nature of fortifications themselves, including constructed and natural defenses provided by physical topography, are equally important variables. Only by incorporating both bodies of data can the complex patterns caused by competition, aggression, and warfare be fully evaluated.

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ABSTRACT

Rugged landscapes play a significant role in the evolution of behavioral strategies aimed at subsistence and defense. This study presents geographic information system (GIS) analyses based on prehistoric fortifications in Fiji. Utilizing variables such as the distribution of arable land, the presence/absence of defensive features, and the natural defenses inherent in topography, i.e., the accessibility of forts and their commanding views of the landscape, correlations are revealed that are indicative of the costs and benefits of fort location and construction. These in turn yield insights into the origins and frequencies of a variety of defensive and subsistence strategies, and also indicate the degree to which geography plays a role in competitive societies.
Keywords: fortifications, geography, GIS, competition, agricultural investment.